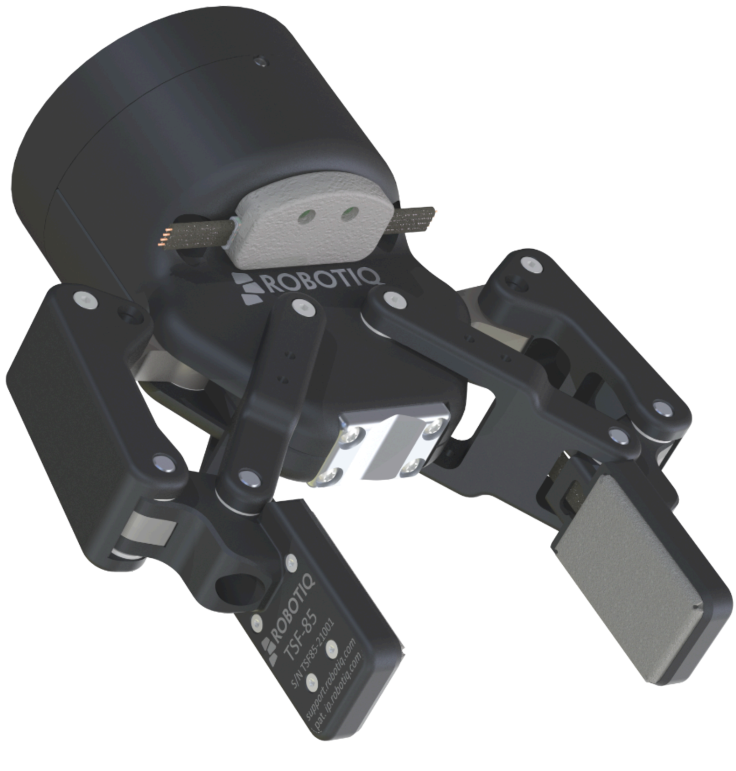
Tactile Sensors TSF-85

User Guide



Version: 1.0.0

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1. Introduction

1.1 Purpose of the guide

This document is intended to be the central point for up-to-date technical information about the Robotiq Tactile Sensors (TSF-85 for the 2F-85 gripper). The target audience is current and future users. Brevity is prioritized, linking to external links as needed (software packages, for example).

1.2 Product Description

The Robotiq Tactile Sensors Fingertips (TSF) are an accessory kit designed to integrate tactile sensing capabilities with Robotiq Adaptive Grippers, enabling advanced robotic applications. The TSF-85 provides three distinct types of feedback signals to the robot controller:

- **Pressure signal:** A 4x7 grid of taxels measures the normal force distribution across the fingertip surface. The signal is the change in capacitance measured by the sensor, represented by the raw counts from the Capacitance to Digital Converter and thus has no specific units.
- **Dynamic signal:** A high-frequency (1000Hz) channel monitors vibrations. This signal has no specific unit as well as it is a measure of the instantaneous change in capacitance.
- **Proprioception signal:** An onboard IMU tracks the orientation of the fingertips. This is necessary because the passive encompassing mechanism of the 2F Gripper prevents complete orientation tracking via the robot encoders alone. The outputs are the raw data from the accelerometers and gyroscopes.

The Tactile Sensors Fingertips replace the standard gripper fingertips. They are available in two configurations:

- Starter Kit (AGC-TIP-TSF-85-STARTER-KIT): Includes the fingertips, associated hardware, a connectivity hub, and a USB cable.
- Replacement Kit (AGC-TIP-TSF-85): Includes the fingertips and associated hardware, intended for replacing consumable components.

Unlike most Robotiq products (such as Grippers, Force Torque Sensors, and Palletizing Solutions), the TSF are subject to rapid evolution. Consequently, the long-term availability of a specific product version cannot be guaranteed. Users with critical requirements for long-term availability, specific new features, or compatibility with particular gripper models should contact Robotiq Support.

1.3 Gripper Compatibility

Gripper model	Tactile sensors compatibility
2F-85	Compatible (TSF-85)
2F-140	Contact Robotiq
3F	Contact Robotiq
Hand-E	Contact Robotiq
Hand-E C10	Contact Robotiq

Table 1: Gripper compatibility

1.4 Intended use

The Tactile Sensor Fingertips deliver rich, high-frequency, multi-modal data directly to your PC (acting as the robot controller) through USB. This tactile feedback provides critical information—like grip pressure distribution—that's often missed by other systems, such as vision cameras. Your robot controller can then use this data, through either AI or traditional programming, to make smart, high-level decisions that adapt the robot and gripper control in real-time.

We provide software examples to get you started with data acquisition quickly. However, you will need to develop your own application-specific software to analyze the data and integrate the sensor feedback into your robot control logic.

Tactile sensors enable advanced capabilities like:

- Handling delicate or fragile objects
- Estimating the pose (position and orientation) of the gripped object
- Detecting when an object is starting to slip
- Distinguishing between different material textures
- Classifying the object that has been picked
- Monitoring and adjusting grip stability

Additionally, you can use the Tactile Sensor Fingertips to passively log vast amounts of data from a tele-operated system. This data is invaluable for training your own AI models to perform the high-level tasks listed above.

1.4.1 Limitations

The Tactile Sensor Fingertips signals are not integrated into the gripper internal control system. An external PC (acting as the robot controller) is therefore required to acquire and process the data. High frequency control of the gripper based on tactile feedback is not possible.

The sensors are also not intended to be used in applications that contains any of the following:

- Manipulation of sharp or rough objects, or any type of object that would create a premature wear of a soft polymer surface.
- Manipulation of liquids.
- Exposure to extreme temperatures (outside of the specified operating range).
- Exposure to corrosive chemicals or solvents.
- Applications involving excessive force or impact beyond the gripper's maximum grip force.
- Use in explosive atmospheres.
- Use in medical or life-support applications.

1.4.2 Environmental limits

The TSF-85 Tactile Sensor Fingertips' environmental limits must adhere to the stricter requirements between those specified in the table below and those of the 2F-85 Adaptive Gripper. Refer to the gripper user manual for the 2F-85 Adaptive Gripper's environmental specifications.

Specification	Value
Operating temperature	0-40°C
Relative humidity	20-80%RH

Table 2: Environmental limits

2. Hardware Installation

2.1 Scope of delivery

TSF-85 Starter Kit for 2-Finger Adaptive Robot Gripper 85-V4 (AGC-TIP-TSF-85-STARTER-KIT)
• 2 x Tactile Sensor Fingertips • 4 x Dowel Pins (dia. 2 x 6 mm) • 2 x Screws (M5-0.8 x 12 mm SHCS) • 1 x Main hub board • 1 x USB cable Note: Two (2) fingertips are required per gripper.

TSF-85 Replacement Kit (AGC-TIP-TSF-85)
• 2 x Tactile Sensor Fingertips • 4 x Dowel Pins (dia. 2 x 6 mm) • 2 x Screws (M5-0.8 x 12 mm SHCS) Note: Two (2) fingertips are required per gripper.

⚠️No plug-and-play software is provided with the tactile sensors.

⚠️Tactile Sensor Fingertip sensitivity will decrease over time at a rate dependent on the application. This sensitivity decrease is considered normal wear (not covered by warranty).

⚠️TSF-85 are only compatible with the 4th version of the 2F-85 Adaptive Gripper (produced since 2019, serial number is C-XXXXX with 5 numbers).

2.2 Required Tools

The following tools are required to install the TSF-85 fingertips and its connectivity hub:

- 2mm hex key
- 3mm hex key
- 4mm hex key
- flat screwdriver to open/close manually the gripper

2.3 Installation steps

⚠️**Caution:** Exercise care when handling the tactile sensors' flat ribbon cable. The pins on the end of the cable are delicate and easily damaged.

1. **Connectivity Test (Optional)**

   Prior to full assembly, you may connect the Tactile Sensors to the USB Connectivity Hub to confirm successful communication.

   Note: Disconnect the sensors before proceeding to the subsequent assembly

steps.

2. ⚠️**Delicate step**

   Feed the flat ribbon cable of the first tactile sensor through the interphalangeal joint.

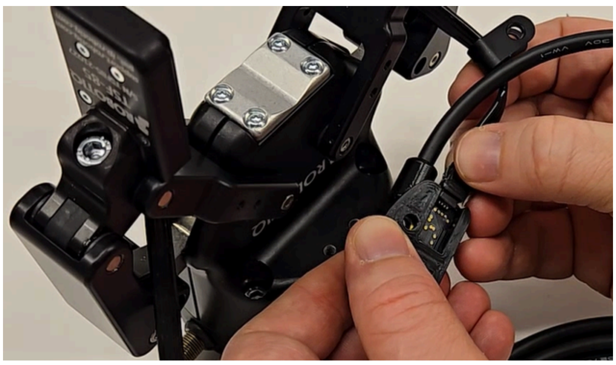
   Avoid applying excessive force to the connectivity pins.

3. **Mount the Tactile Sensor Fingertip:** Align the tactile sensor fingertip with the two pins on the finger, and secure it using the provided M5 screws.

   Insert the Cable Holder: Slide the cable holder onto the ribbon cable.

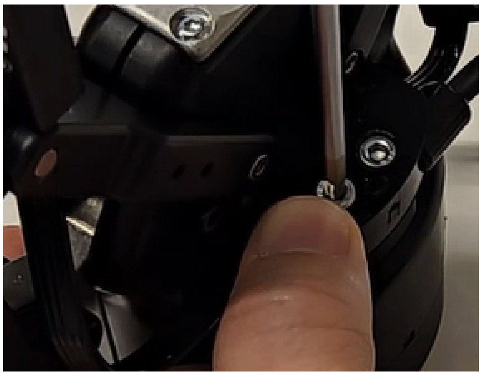
4. Repeat steps 2 and 3 for the remaining tactile sensor fingertip.

5. ⚠️**Delicate step**
   Connect the flat ribbon cables from each tactile sensor to the bottom of the USB Connectivity Hub (the hub is not yet mounted).



6. Secure the connectors by placing the connector clip onto the hub.

   Mount the USB Connectivity Hub (with the attached connector clip) onto the gripper using the supplied screws.



7. Secure the two cable holders to the gripper fingers using the supplied screws.

8. **Verify Cable Management:** Manually open and close the gripper by driving the mechanism with a screwdriver, and move the passive encompassing mechanism to ensure the Tactile Sensors Fingertips' cables are properly managed and do not snag or stretch.

   Adjust Ribbon Cable (if needed): If the flat ribbon cable appears too loose or too taut in any section during the verification, adjust its slack.

9. Secure the 5m USB cable to the robot arm using an appropriate strain relief accessory (not provided).

   Ensure there is enough slack in the cable to allow the robot arm to move freely to all joint positions without excessive cable tension.

10. Connect the USB cable to your signal-processing computer.

3. Specifications

3.1 Mechanical Specs

Specification	Value
Width	28.4 mm
Height (from mounting surface)	44 mm
Thickness (fingertip)	10.9 mm
Distance from pad surface to mounting screw	17.9 mm

Table 3: Mechanical specs of the Tactile Sensor Fingertips

3.2 Electrical Specs

Specification	Value
Communication interface	USB2 (USB-A connector)
Current consumption	<500mA (powered through USB)

Table 4: Electrical Specs

3.3 Sensing Specs

3.3.1 Pressure signal

Specification	Value
Taxel distribution	4 x 7 (columns x rows)
Refresh rate	60Hz
Resolution for even force (typical, sum of all taxels)	0.011 N/count 0.5N
Noise level (standard deviation over 1s, sum of all taxels, typical)	0.5N (50 counts)
Noise level (standard deviation over 1s, single taxel, typical)	8 counts

Table 5: Pressure signal

3.3.2 Dynamic signal

Specification	Value
Resolution	TBD
Max Range Raw	±32767
Convert to mV	Raw x 1.024/32767
Refresh rate	1000Hz

Table 6: Dynamic signal

Current software outputs raw signals.

3.3.3 Proprioception (IMU)

Specification	Value
Refresh rate	1000Hz
Accelerometer FSR	±2 g
Gyroscope FSR	±250 °/s

Table 7: IMU signal

Current software outputs raw signals.

4. Software & Communication

The accompanying software is intended as a foundation for establishing connectivity with the Tactile Sensor Fingertips. Note that no complete application software is included.

For hardware testing and troubleshooting, use the Sensor Quickstart Python scripts. These scripts include bash and BAT files for running on Linux and Windows. Additionally, a web viewer is provided to visualize the various signals.

The other software packages on the Robotiq Github (links below) are provided as is, without direct support from the Robotiq support team. The users are invited to ask questions and make requests on the Github repository directly.

Software Link	Description	Type of support
Sensor Quickstart Python script	Minimal example, recommended as a starting point to test / troubleshoot the sensor. Has a web viewer (for demo purposes) and can run on Linux and Windows.	Direct (Contact Robotiq for support)
C++ SDK	Community support (ask your questions/request on Github)	Community
ROS	Community support (ask your questions/request on Github)	Community
NVIDIA	Coming soon	Community

Table 8: Different softwares related to the Tactile Sensor Fingertips

4.1 Best practices for integration within a robot cycle

Each taxel on each sensor has its own unique bias and response which may be standardized by calculating the bias and the gains needed to achieve a uniform response. Please refer to Appendix A for an example of a typical sensor's response and hysteresis.

A. Calculating the Bias

1. Take a number of baseline samples (recommended 1000) of the unloaded sensor.
2. Calculate the average reading on each taxel over the baseline samples. This provides your per taxel baseline bias.
3. Subtract this bias from the readings.

For maximum repeatability, this biasing should be done before any load on the sensor, for example before a grasp. Typical baseline bias values range from 9000-30000 CDC counts.

Given the inherent hysteresis in the sensor signal and the variability in taxel sensitivity, the following best practices are recommended for accurate load measurement:

B. Periodic Taxel Sensitivity Calibration

To ensure accurate readings, periodically calibrate the sensitivity of each individual taxel by following this routine:

1. **Gripper Activation:** Power on and activate the gripper.
2. **No-Load Baseline:** With the gripper in the fully open position, record and

store the signal value for each taxel. This is the "no load" baseline.

3. **Max Uniform Load:** Close the gripper at maximum force and maximum speed (or with a known maximum uniform load object).
4. **Signal Storage:** Record and store the signal value for each taxel under this "max uniform load."
5. **Sensitivity Calculation:** Calculate and store the sensitivity of each taxel using the difference between the "max uniform load" signal and the "no load" baseline.
6. **Calculate the Gain:** Calculate and store the values that aligns each taxel to a similar value under "max uniform load". Refer to Appendix B for an example.

Tip: If the fingertips seem slightly misaligned, try closing the gripper on a flat rigid plate or a thin deformable material such as leather or foam to distribute the forces more evenly over the taxels.

C. Taxel Signal Compensation During a Robot Cycle

Implement the following steps within the robot's operating cycle to compensate for hysteresis and signal drift:

1. **Cycle Baseline:** Immediately before the gripping action, and with the gripper open, store the current "no load" signal as a baseline for the current cycle. This compensates for short-term drift and hysteresis.
2. **Gripping Action:** Close the gripper using the desired application settings (force, speed, position).
3. **Scaled Load Measurement:** Once the grip is complete, use the current signal from each taxel, along with the stored values (cycle baseline and calculated sensitivity gain), to accurately scale the signal and determine the load on each taxel.

Note on Load Limits and Non-Linearity:

- It is possible for the pressure on individual taxels to exceed the "max uniform load" established during the calibration, depending on the object's geometry and composition.
- For applications requiring greater precision, be aware that taxel sensitivity is not linear. Advanced users may opt to implement a more complex, multi-point calibration procedure to better characterize the load response across the full range of each taxel. Please refer to Appendix B and C for an example.

5. Maintenance & Troubleshooting

Maintain the 2F Adaptive Robot Gripper according to the manufacturer's recommendations (refer to the gripper manual).

Regarding the Tactile Sensor Fingertips, perform regular inspections to confirm they are clean and in proper working condition, ensuring the cover skin is not punctured or damaged. Also, verify that the cable management for both the fingertips and the USB cable permits all necessary gripper and robot movements without placing excessive strain on the cables.

USB Hub LED State	Associated TSF Status
Main LED solid green	Powered (USB cable connected)
Main LED blinking green (2Hz)	Bootloader mode, firmware not loaded (contact Robotiq support)
Main LED OFF	USB Hub not powered
Finger LED solid green	Active communication (valid packets) between the hub and the Tactile Sensor Fingertip
Finger LED OFF	Fingertips not connected, not powered or not functional
Finger LED Flashing	Fingertips seeking connection

Table 9: LED states for troubleshooting

6. Warranty and Support

Robotiq warrants the TSF-85 against defects in material and workmanship for a period of one year from the date of reception when utilized as intended. Robotiq also warrants that this equipment will meet applicable specifications under normal use. The fingertips warranty covers DOA (Dead on Arrival), but not the normal wear and decrease of sensitivity associated with the use of tactile sensor fingertips.

Warranty applies under the following conditions:

- Usage respects the operating and storage conditions specified in the Environmental and Operating Conditions section
- Proper installation specified in the Installation section and the following subsections.
- One year from shipment date
- Usage respects maintenance specified in the Maintenance section.

Exclusions

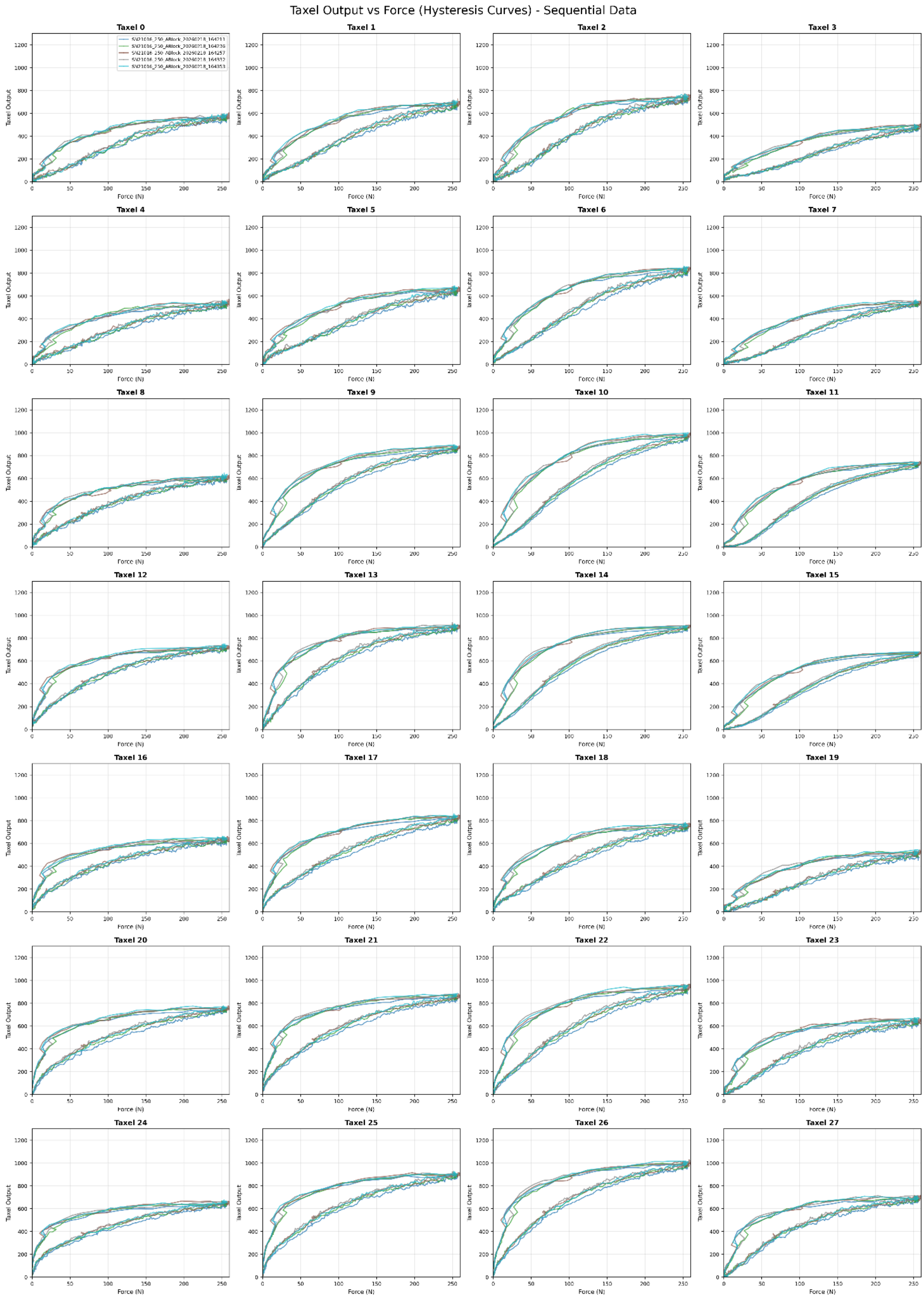
This warranty excludes all consumable parts, such as fingertips and their normal wear. Tactile Sensor Fingertip sensitivity will decrease over time at a rate dependent on the application. This sensitivity decrease is considered normal wear (not covered by warranty).

This warranty also excludes failure resulting from: improper use or installation, normal wear and tear, accident, abuse, neglect, fire, water, lightning or other acts of nature, causes external to the Gripper or other factors beyond Robotiq's control.Robotiq reserves the right to make changes in the design or construction of any of its products at any time without incurring any obligation to make any changes whatsoever on units already purchased.

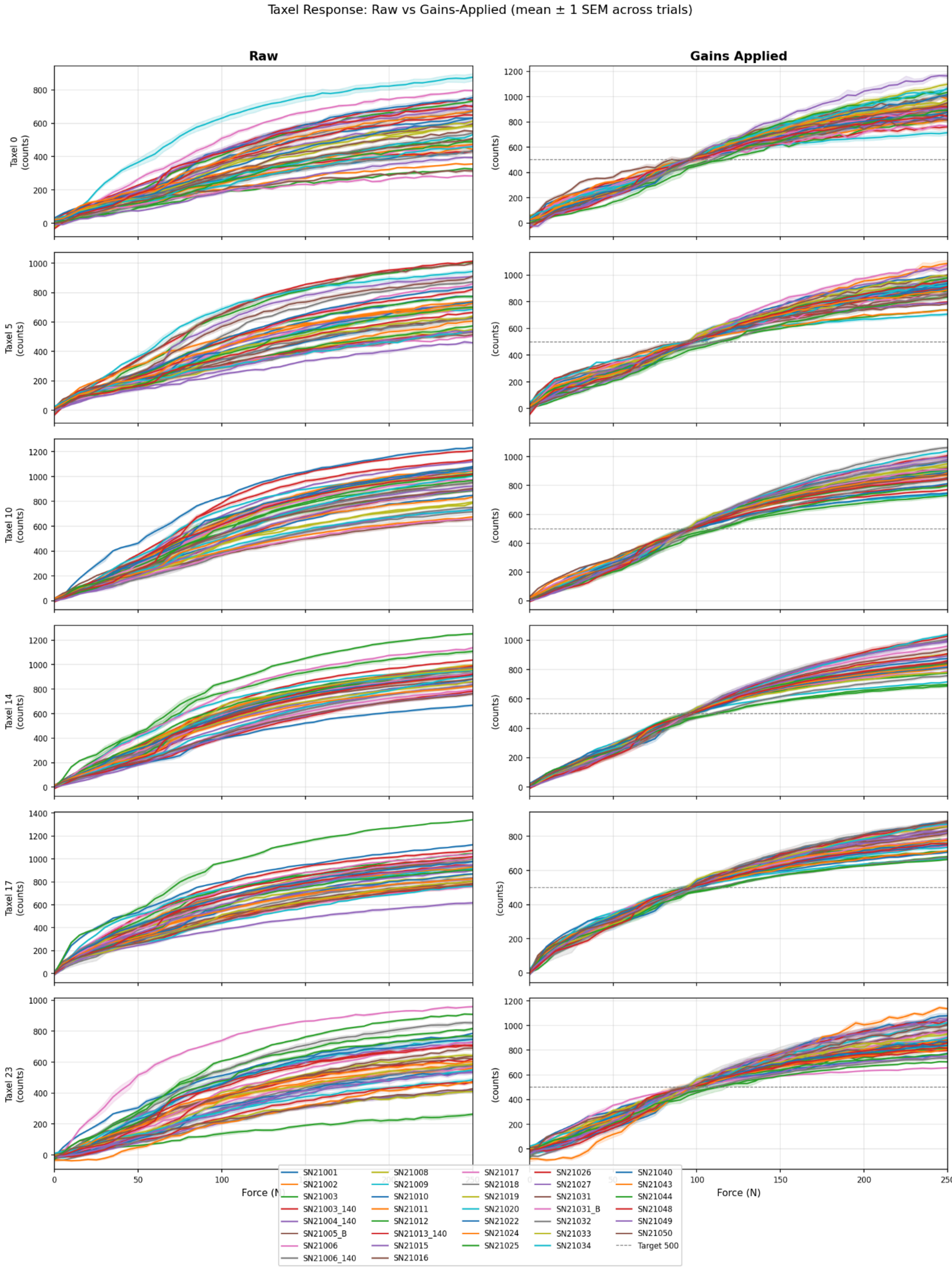
7. Document Revisions

Date	Modifications
2026-03-05	Initial Release

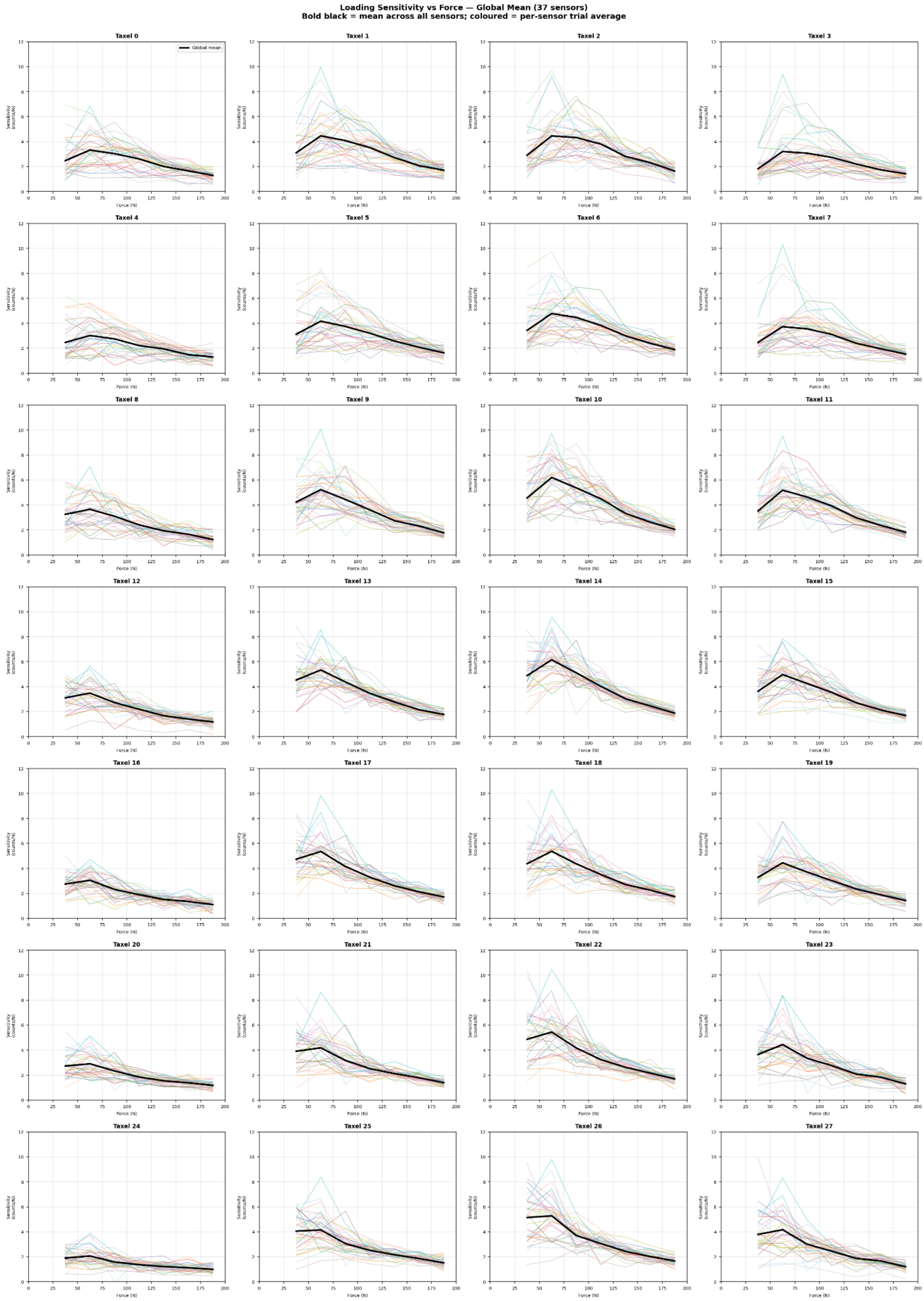
Appendix A - Typical pressure vs force signal for all 4x7 taxels



Appendix B - Impact of a gain calculated to align the 100N response to 500 CDC counts on the sensor outputs



Appendix C - Average sensitivity over 37 sensors based on 25N steps (counts/N)



Appendix D - Dynamic vs Accelerometer to external disturbance